COMPARISON MANUAL AND CVT TRANSMISSION FOR A CAR UNDER 1 LITER ENGINE

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Report submitted in partial fulfilment of the requirements
for the award of the degree of
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I certify that the project entitled "Comparison Manual and CVT Transmission for a Car Under 1 Liter Engine "is written by Mohammad Azlan bin Abdul Aziz. I have examined the final copy of this project and in my opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. I herewith recommend that it be accepted in partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

This thesis presented about comparison manual and CVT transmission. This thesis deals with analysis on performance of transmission for a car under 1 liter engine. The objective of this thesis is to compare the performance of transmission between manual transmission and CVT transmission. Besides that, the purpose of this thesis is to analyze the performance of the Manual Transmission and the CVT Transmission for a car under 1 liter engine. This thesis also purposes to study the suitability using CVT for a car under 1 liter engine. Manual transmission and CVT transmission have their own advantages and one of that is better in their performance. In performance, there are many category that compared consist of power available, tractive force, fuel consumption and many more. The data used for the analysis is obtained through calculation using specification data that has got from brochure which is downloaded from Toyota's official web because this model only market at Europe. This model fulfilled this project because it had two types of transmission which is CVT transmission and Manual Transmission. The post-processing method was performed using manual calculation with certain engineering formula and graph is plotted by using assistance software such as Microsoft Excel. The post-processing method to analyze the performance of transmission was performed using the SAE definition. From the results, it is observed that the performance of CVT is better than manual transmission. It is also observed that Manual Transmission is better than CVT in term of fuel consumption for a car under 1 liter engine. Besides that, CVT are suitable to use for a car under 1 liter engine because it gives more power and ride comfort ability. Future work, this comparison between manual transmission and CVT must do in experimental or simulation since CVT technology just begun to blossom to Malaysia. There are many factors that required to do research by experimental especially in transmission's performance and driveability.

ABSTRAK

Tesis ini membentangkan perbandingan tentang penghantaran manual dan penghantaran CVT. Tesis ini berkaitan dengan analisis terhadap prestasi penghantaran untuk kereta berenjin di bawah 1 liter. Tujuan dari tesis ini adalah untuk membandingkan prestasi penghantaran antara transmisi manual dan transmisi CVT. Selain itu, tujuan dari tesis ini adalah untuk menganalisis prestasi penghantan Manual dan penghantaran CVT untuk kereta berenjin di bawah 1 liter. Tesis ini juga bertujuan untuk mempelajari kesesuaian menggunakan CVT untuk kereta berenjin di bawah 1 liter. Penghantaran manual dan penghantaran CVT memiliki kelebihan mereka sendiri dan salah satu yang lebih baik dalam prestasi mereka. Dalam prestasi, ada banyak kategori yang dibandingkan terdiri daripada kuasa, gaya traksi, penggunaan bahan bakar dan banyak lagi. Data yang digunakan untuk analisis diperolehi melalui perhitungan dengan menggunakan data spesifikasi yang telah didapati dari brosur yang dimuat turun dari Laman web rasmi Toyota kerana model in hanya berada di pasaran Eropah. Model ini memenuhi projek ini kerana mempunyai dua jenis penghantaran iaitu CVT penghantaran dan Transmisi Manual. Kaedah pemprosesan dilakukan menggunakan perhitungan manual dengan rumus tertentu dan graf diplot dengan menggunakan software bantuan seperti Microsoft Excel. Kaedah yang digunakan untuk menganalisis prestasi penghantaran dilakukan dengan menggunakan definisi SAE. Dari hasil, diperhatikan bahawa prestasi CVT lebih baik daripada penghantaran manual. Hal ini juga didapati bahawa Transmisi Manual lebih baik dari CVT dalam hal penggunaan bahan bakar untuk kereta berenjin di bawah 1 liter. Selain itu, CVT sesuai digunakan untuk kereta berenjin di bawah 1 liter kerana memberikan kekuatan lebih dan keselesaan semasa pemanduan. Pada masa datang, perbandingan antara penghantaran manual dan CVT harus dilakukan dalam eksperimen atau simulasi kerana teknologi CVT baru sahaja mula berkembang di Malaysia. Ada banyak faktor yang diperlukan untuk dilakukan kajian secara eksperimen terutama dalam prestasi penghantaran dan kebolehan pemanduan.

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LIST OF SYMBOLS

A	Cross-section area
C_d	Aerodynamic drag coefficient
g	Gravitational force
G	Overall drive ratio
G_{fd}	Final gear ratio
m	Mass of vehicle
N_e	Engine speed
P	Power available
P_{req}	Power required
R_a	Aerodynamic drag resistance
R_r	Rolling resistance
R_g	Gravitational resistance
R_i	Acceleration resistance
r	The radius of the tyre
T_e	Engine Torque
T_w	External torque
TF_w	Tractive effort
v	vehicle speed
$\dot{v}$	Acceleration in the direction of motion of the vehicle
ρ	Air density
θ	Road slope
η	Efficiency

LIST OF ABBREVIATIONS

CVT	Continuously Variable Transmission
FYP	Final Year Project
IC	Internal combustion
RPM	Revolution per Minute
RWS	Road wheel speed
SAE	Society of Automotive Engineers
VDP	Variable-Diameter Pulley

CHAPTER 1

INTRODUCTION OF THE PROJECT

1.1 INTRODUCTION

Transmission is one of part that is important after engine part. It can assume as the heart of the drivetrain. It is because gasoline engines develop their torque over a very narrow speed range, several gears are needed to reach useful road speeds. A manual transmission is a type of transmission uses a driver operated clutch, typical operated by a pedal or lever, for regulating torque transfer from internal combustion and gear shift, either operated by hand. The CVT is a transmission which can change steplessly through an infinite number of effective gear ratios between maximum and minimum values.

There has been a clear trend in the automotive industry in recent years toward increased ride comfort and fuel efficiency. As power transmission unit, transmission plays an important role in vehicle performance and fuel economy (Lechner, 1999). Manual transmission have an overall efficiency of 96.2 percents, this is the highest efficiency value for any type of transmission. Current production automatics have been improved to provide an efficiency of not more than 86.3 percents and CVT's have an overall efficiency of 84.6 percents. However, the major advantage of CVT is that it allows the engine to operate in the most fuel-efficient manner (Klunger, 1999).

In order to seek the best performances, a research will be carried out to the car under 1 liter engine. Toyota iQ 1000cc is selected in this study because only this model which have manual and continuously variable transmission for a car under 1 liter engine. A calculation was required to estimate which one have better performance

especially in performance characteristic. The best method to calculate the performance is by manual calculation with certain formula and graph is plotted by using assistance software such as Microsoft Excel.

1.2 PROBLEM STATEMENT.

The performance of the vehicles depends on so many factors and one of it is the type of transmission. Nowadays, there are three types of transmission being used all around the world that effect the engine and each of it has their own advantages and disadvantages. But the best or ideal transmission for the vehicle still not exist and there are too many space for improvement for researcher to find the perfect one and to make sure the performance of the vehicle at the high level.

Manual transmission is familiar and widely used in passenger car at this age. CVT have become increasingly popular in the automotive marketplace in the past decade. Normally, the CVT is used in heavy vehicles such as trucks, buses and etc. This is because the CVT can provide high power and torque to facilitate in controlling of heavy vehicles. So, Manual and CVT transmission have their own advantages and of one of their advantage is better in performances. But, the question is which transmission provides better performance?

1.3 OBJECTIVES

The objectives of this project are as follows:

i. To compare the performance of transmission between Manual Transmission and CVT transmission based on Toyota iQ 1.0 liter.
ii. To analyze the performance of the Manual Transmission and the CVT Transmission for a car under 1 liter engine
iii. To study the suitability using CVT for a car under1 liter engine.

1.4 PROJECT SCOPES.

This project is focusing on comparing between CVT Transmission and Manual Transmission in terms of performance. To complete this project, the following actions are required:

i. Study of manual transmission and CVT transmission based on technical specification of Toyota iQ 1.0 liter on the plane road.
ii. Study of the CVT Transmission mechanism.
iii. Study of the Manual Transmission mechanism.
iv. Study of vehicle dynamics.
v. Compare the CVT Transmission and Manual Transmission performance by using the graph

1.5 METHODOLOGY AND FLOW CHART.

Methodology is one of the most important things to be considered to ensure that the project will run smoothly and will get the expected result. It will be discuss on the process of the project due to the flow chart or more specifically due to the Gantt chart. In this methodology, there are several steps that must followed in order to ensure that the objective of the project can be achieved starting from the literature finding until submitting the report. Below are the steps of the project which briefly being shortlisted into the flow chart.

FLOW CHART

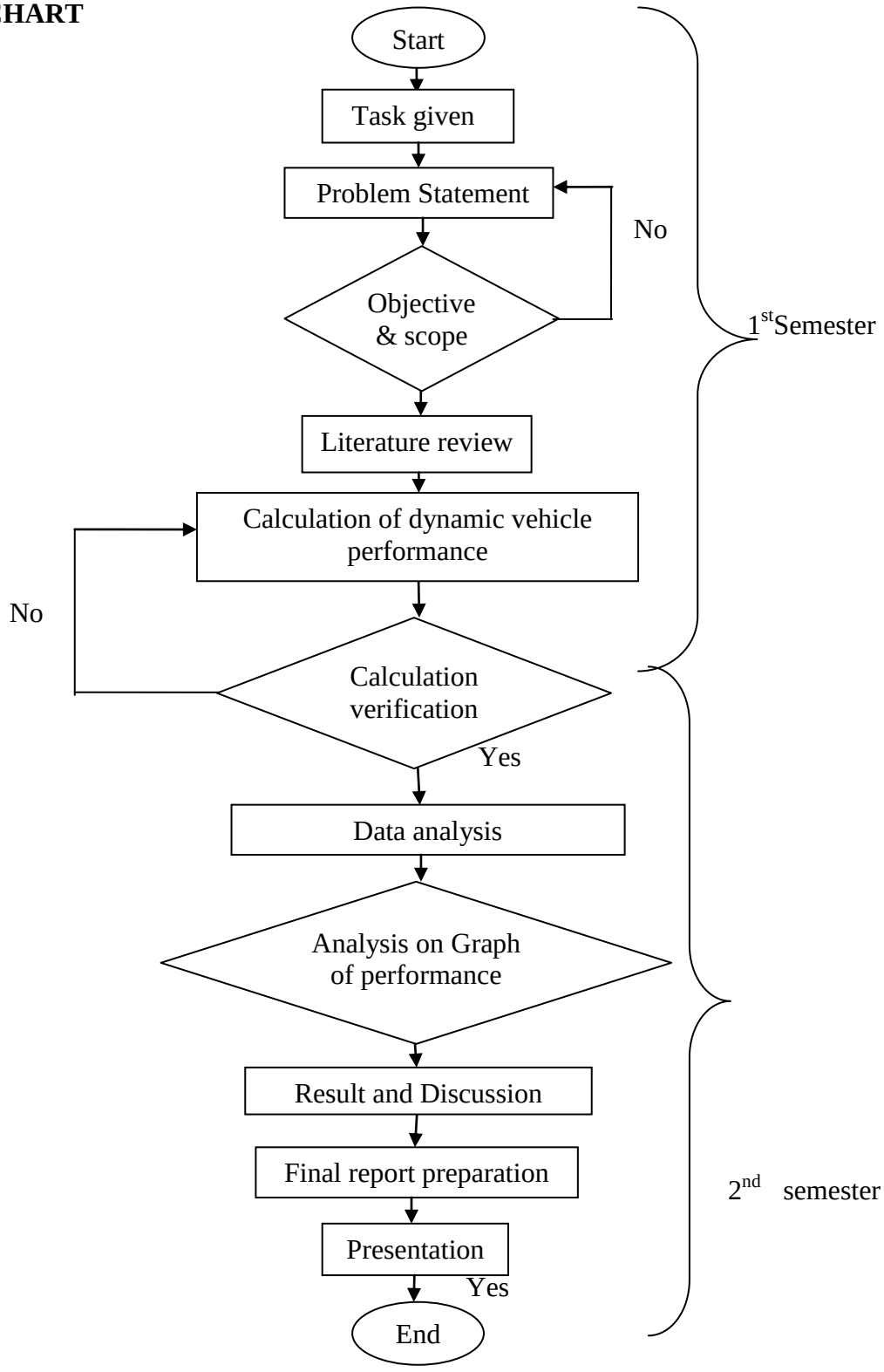

Figure 1.1: Flow Chart of Project

1.6 STRUCTURE OF THESIS.

This thesis purposes to study comparison between Manual transmission and CVT Transmission. Besides that, this thesis also aims to analyze the performance of the Manual Transmission and the CVT Transmission for a car under 1 liter engine. This thesis consists of five (5) chapters.

First chapter describes overall framework of basic information of this project such as introduction, problem statement, objective of the project, project scope and structure of thesis was verified. The main ideas of this project were stated in introduction.

In second chapter, various reviews on theoretical topics which are required as a background study were present. Every important information and theoretical study related to this project is stated in this chapter. Brief explanations about transmission, history, types, and advantages and disadvantages of transmission to achieve the project objectives are reviewed. Some of the explanations give extra information which is useful in conducting this project.

In third chapter, all the method used when conducting the project was described including explanation. The overall methodology sequence are mentioned and explained in detail.

Otherwise, chapter four is about result and discussion about project. This chapter explains the result and analysis that got from the graph.

The conclusion of overall project, recommendation and future works are stated in fifth chapter of the thesis. The conclusion made based from result obtained, the encountered problem lead to recommendation to troubleshot the predicaments. The area o f improvement will be the source of future projects.

Finally, the references of this project were listed and follow by appendices. The related tables are included in appendices for general review.

CHAPTER 2

LITERATURE REVIEW

2.1 HISTORY AND DEVELOPMENT OF DRIVETRAIN.

A car receives power from the engine but it is the transmission that helps utilize engine power efficiently. The gearbox in a car brings variety to driving and a very responsive transmission can make a big difference in ride quality for the occupants. Most cars today come installed with good transmissions.

The earliest transmissions were all of manual type. Manual transmissions still continue to be just as popular as they used to be for the sole reason that they give the driver a sense of thrill through the ability to shift gears up or down at any desired moment. In 1894, the modern transmission was introduced by a pair of Frenchmen who are Louis-Rene Panhard and Emile Levassor (Bohen, 2006). By 1904, the new transmissions were on most cars. The basic concept survives today, with many improvements, of course, and one major change. Introduced by Cadillac in 1928, it's called a synchromesh transmission. It synchronizes gear speeds before shifts so the gears mesh smoothly and shifting is easier for drivers (Bohen, 2006).

The automatic transmission that resembles what's on today's cars got its start in 1948 as Buick's two-speed Dynaflow. Detroit's Big Three and other carmakers soon had versions on all sorts of models. Chevy had the Powerglide, Ford the three-speed Fordomatic and Merc-O-Matic (made by Borg-Warner), Chrysler the M-6 Torque Converter Automatic. As the last name indicates, the innovation was a torque converter, which replaced the fluid coupling (Bohen, 2006).

Though similar to its predecessor, with both eliminating the need for mechanical clutches, the torque converter also multiplied torque at low engine speeds, increasing acceleration. An interesting fact about both fluid couplings and torque converters is that they get power to the wheels even though the only direct connection between the engine and the transmission is through the transmission fluid (Bohen, 2006).

By the 1960s, three-speed torque-converter automatics dominated. They gave way in the 80's to overdrive transmissions with four forward speeds and a lockup feature that increased fuel efficiency. Starting in the late 80's, engine computers or separate transmission chips took greater control of transmissions, improving shift quality, dropping shift times and making semi-automatic shifting without clutches possible (Bohen, 2006).

To say that the CVT is nothing new would be a gross understatement: Leonardo da Vinci sketched his idea for CVT in 1940 (Birch, 2000). In automotive applications, CVT's have been around nearly as long as car themselves, and certainly as long as conventional automatics. General Motors actually developed a fully toroidal CVT in the early 1930s and conducted extensive testing before eventually deciding to implement a conventional, stepped-gear automatic due to production (Yamaguchi, 2000). British manufacturer Austin used a CVT for several years in one of its smaller cars, but "it was dropped due to its high cost, poor reliability, and inadequate torque transmission" (Yamaguchi, 2000). Many early CVTs used a simple rubber band and cone system, like the one developed by Dutch firm DAF in 1958 (Birch, 2000). However, the DAF CVT could only handle a 0.6L engine, and problems with noise and rough starts hurt its reputation (Yamaguchi, 2000). Uninspired by these early failures, automakers have largely avoided CVTs until very recently.

2.2 CONTINUOUSLY VARIABLE TRANSMISSION

2.2.1 Introduction of CVT

In the last decades, a growing attention has been focused on the environmental question. Governments are forced to define standards and to adopt actions in order to reduce the polluting emissions and the green-house gasses. To reduce vehicles' gas emissions in relatively short times, a great deal of research has been devoted to find new technical solutions, which may improve the emission performances of nowadays internal combustion (IC) engine vehicles. A very good solution may be that of using a CVT which is able to provide an infinite number of gear ratios between two finite limits. CVT transmissions are even potentially able to improve the performances of classical IC engine vehicles, by maintaining the engine operation point closer to its optimal efficiency line. Several studies have shown, indeed, that CVTs may improve the fuel savings and reduce the vehicle polluting emissions. For instance, a mid class CVT car may achieve fuel savings of about 10% in comparison to the traditional manual stepped transmission (Brace et al., 1997; Brace et al., 1999; Mangialardi et al., 2002; Carbone et al., 2004).

A CVT (see Figure 2.1) is a transmission which can gradually shift to any effective gear ratios between a set upper and lower limit. In contrast, most transmissions equipped on production cars have only 4-6 specific gear ratios that can be selected. The almost infinite variability of a CVT allows the engine to maintain a constant speed while the vehicle increases in velocity. This can result in better vehicle performance if the CVT is shifted such that the engine is held at the RPM that it runs most efficiently at and/or produces the most power (Gibbs, 2009)

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Physical limitations of strength and friction have in the past restricted the CVT transmission torque handling capabilities to light-duty applications such as lawn mowers, ATVs, and snowmobiles. There was very little desire to develop them to their full potential. However, a renewed public outcry for improved vehicle efficiency combined with advancements in lubricants and materials have sparked new interests in

CVTs. They have now been proven to support the torque requirements for production vehicles, buses, heavy trucks, and earth-moving equipment (Gibbs, 2009).

Figure 2.1: CVT Transmission

Source**:** Takahashi, M. et al. (1999)

2.2.2 CVT's Basic Principle.

The CVT is an automatic transmission that uses two pulleys with a steel belt running between them. To continuously vary its gear ratios, the CVT simultaneously adjusts the diameter of the "drive pulley" that transmits torque from the engine and the "driven pulley" that transfers torque to the wheels. From Figure 2.2 (a), the diameter of driven pulley increase but the diameter for drive pulley decrease. It is occurred because the power transmitted from engine to driveshaft. It is vice versa for diameter driven pulley and drive pulley for Figure 2.2 (b) which is in high gear condition. Besides that, because it is continuously variable, the CVT not only avoids the shift-shock and peaks and dips in torque transmission associated with a conventional AT, but also maintains optimum torque for any given power demand. This makes the CVT an exceptional transmission solution that delivers smooth and powerful driving performance together with excellent fuel economy (Nissan Motor, 2008).